IDF-00015
Revision 0

Integrated Disposal Facility Action Leakage Rate for Leachate Storage Tanks

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract 89303320DEM000030

CPCCo Central Plateau Cleanup Company

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Richland, Washington 99352

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FMP#: ECR-20-001348

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Document Type: CALC Program/Project: IDF

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Date Published
March 2021

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DATE:
Mar 31, 2021
HANFORD
RELEASE

APPROVED
By Janis Aardal at 9:44 am, Mar 29, 2021

Release Approval	Date	Release Stamp

Printed in the United States of America

Total pages: 12

CHPRC REVIEW CHECKLIST

Document Reviewed:
IDF-00015, Integrated Disposal Facility Action Leakage Rate for Leachate Storage Tanks, Revision 0

Scope of Review:
Calculation validation

Yes	No	N/A		
☐	☐	☒	*	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐		Problem completely defined.
☐	☐	☒		Accident scenarios developed in a clear and logical manner.
☒	☐	☐		Necessary assumptions explicitly stated and supported.
☐	☐	☒		Computer codes and data files documented.
☒	☐	☐		Data used in calculations explicitly stated in document.
☒	☐	☐		Data checked for consistency with original source information as applicable.
☒	☐	☐		Mathematical derivation checked including dimensional consistency of results.
☒	☐	☐		Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☐	☐	☒		Software input correct and consistent with document reviewed.
☐	☐	☒		Software output consistent with input and with results reported in document reviewed.
☒	☐	☐		Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☒	☐	☐		Safety margins consistent with good engineering practices.
☒	☐	☐		Conclusions consistent with analytical results and applicable limits.
☒	☐	☐		Results and conclusions address all points required in the problem statement.
☐	☐	☒	*	Format consistent with appropriate NRC Regulatory Guide or other standards.
☒	☐	☐		Review calculations, comments, and/or notes are attached.
☐	☐	☒		For calculations in which codes/spreadsheets (e.g., RADIDOSE, GENII, etc) are used, is the latest revision used? Is the User Authorized?
☐	☐	☒		Hazard controls established are appropriate for the hazards including selection using the appropriate hierarchy (e.g., engineered over administrative).
☐	☐	☒		The preventive or mitigative credit assigned to hazard controls are appropriate, and the basis is documented.
☒	☐	☐		**Document approved.**

Jared W. Carson Carson, Jared W Digitally signed by Carson, Jared W Date: 2021.03.29 08:41:00 -07'00'

Reviewer (Printed Name and Signature) Date

*Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

Contents

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Terms

ALR	Action Leakage Rate
CDN	Composite Drainage Net
IDF	Integrated Disposal Facility
LDS	Leak Detection System
EPA	Environmental Protection Agency

1.0 Purpose/Objective:

The purpose of this calculation is to determine the Action Leakage Rate (ALR) for the Leachate Storage Tanks at the Integrated Disposal Facility (IDF), as required by WAC 173-303-650.

The ALR is defined in The Final Rule (EPA, 1992a, 40 CFR Part 264.302) and WAC-173-303-650, Surface Impoundments *as "the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 foot."*

2.0 Summary of Results and Conclusion

As the Leachate Storage Tanks at IDF are classified as Surface Impoundments , an ALR has to be determined for each tank per WAC 173-303-650. This calculation applies a method proposed by the Environmental Protection Agency (EPA), along with a conservative factor of safety to determine an ALR of approximately 579 gal/(acre*day) for each of the IDF Leachate Storage Tank.

This value for the ALR is much lower than the capacity of the sump pump that removes liquid from the Combined Sump.

3.0 Introduction/Background

The Hanford Integrated Disposal Facility is a double-lined landfill at the U.S. Department of Energy Hanford Site that is intended to be a near-surface disposal facility for Immobilized Low-Activity Waste from the Waste Treatment Plant. Additionally, the IDF will receive low-level waste and mixed low-level waste from various Hanford Site operations.

The IDF has been constructed and is currently in a pre-operational condition awaiting the development of an operations facility and supporting infrastructure prior to the authorization to receive waste.

The landfill leachate handling system is designed to collect leachate from precipitation and dust suppression that will be monitored, collected, and treated as necessary. Part of this leachate handling system are two storage tanks that are subject to regulations under WAC 173-303-650 for Surface Impoundments.

4.0 Method of Analysis:

This calculation follows the methodology of RPP-18486, Appendix C10 which calculated the ALR for the IDF Cells, and RPP-18486 Appendix C.6.b2 for applying reduction factor values to the published transmissivity of the drainage layer composite.

Per the above definition of ALR, the EPA provides a formula based on Darcy's Law for calculating the flow capacity of the LDS that determines the ALR. This assumes the leak originates from a single hole in the primary liner, at the bottom of the tank.

$$Q = k\ h \tan\alpha\ B \qquad \text{Eq. (1)}$$

where: Q = flow rate in LDS, per acre
k = hydraulic conductivity of drainage medium in LDS
h = head on secondary liner
α = slope of LDS
B = width of flow in LDS, perpendicular to flow direction

One major uncertainty associated with equation (1) is determining the value of B, which is a complex function and in part dependent on the other parameters. Additional information and guidance is provided by EPA in a background document (EPA, 1992b).

By assuming that the shape of the wetted area down slope from the hole is parabolic and that the head on the secondary liner is greater than the thickness of the drainage layer, EPA rewrites equation (1) to read:

$$Q = k\ D\ (2h - D) \qquad \text{Eq. (2)}$$

where: D = thickness of the drainage layer
k D = transmissivity ψ
other parameters are the same as in equiation (1).

As seen in the example below (Figure 1), the drainage layer between the primary and secondary liners will by design allow leachate to flow to the combined sump.

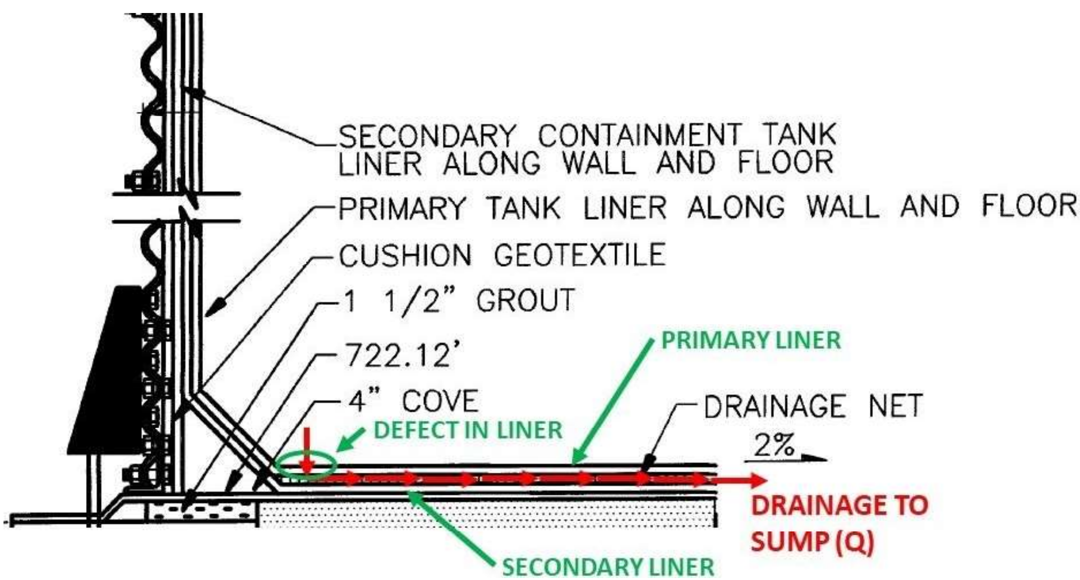

Figure 1: Cross section of tank, with leak path to sump highlighted.

5.0 Input Data, Assumptions, and Known Quantities:

Calculation Inputs and Known Quantities:

$h := 1\ ft$ head on liner system as defined by regulations.

$D := 220\ mil = 0.018\ ft$ thickness of Composite Drainage Net (CDN), Transnet 220-2-8, as defined in 50423-SUPPL7 (copy in Appendix A).

$\psi := 2.25 \cdot 10^{-4}\ \frac{m^2}{s} = \left(2.422 \cdot 10^{-3}\right)\ \frac{ft^2}{s}$ transmissivity of the CDN (Transnet 220-2-8) per 50423-SUPPL7 (copy in Appendix A).

Assumptions:

1. Published transmissivity of the drainage layer was obtained from the manufacturer's laboratory test data at a pressure of 15,000 psf. As the compressive pressure on the liner at the bottom of the tank is less than 1,000 psf, reduction factors for elastic and creep deformation were assumed to be more in line with published factors for landfill covers.
2. Defect frequency of one per acre and a defect size of 0.005 square inch, as recommended in EPA, 1992b for calculating leakage rate.

6.0 Use of Computer Type and Software:

This calculation was prepared on a desktop computer using Mathcad Prime 3.1® to document and organize the report. The mathematical equations that are used in Mathcad are directly observable to the calculation checker for review and validation.

7.0 Calculation:

ALR prior to applying any safety factors:

$Q := \frac{\psi \cdot (2 \cdot h - D)}{1\ acre} = 3102\ \frac{gal}{acre \cdot day}$ assuming one defect per acre. Eq (2)

Factors of Safety / Reduction Factors:

As required by EPA, 1992b, the ALR must include an adequate safety margin to allow for uncertainties in the design, construction, operation, and location of the LDS, waste and leachate characteristics, likelihood and amounts of other sources of liquids in the LDS, and proposed response actions.

MathCad Prime is a registered trademark of Parametric Technology Corp., Needham, MA.

The listed references propose two methods for obtaining this safety factor:

1. EPA, 1992b proposes dividing the above ALR by a safety factor of 2.
2. RPP-18486 Appendix C.6.b2 calculates reduction factors to the transmissivity of the drainage layer based on factors such as as intrusion, creep deformation, and chemical and biological clogging.

This calculation will examine both methods and apply the more conservative safety factor to the above calculated ALR.

Calculate ALR with a safety factor as proposed by EPA, 1992b:

$$Q_{SF1} := \frac{Q}{2} = 1551 \ \frac{gal}{acre \cdot day}$$ assuming one defect per acre. Eq. (3)

Calculate ALR with applied transmissivity reduction factors:

Transmissivity reduction factors:

As the above value for transmissivity was obtained by laboratory testing, reduction factors can be applied to account for factors such as intrusion, creep deformation, and chemical and biological clogging of the CDN.

Reduction factors were applied as below per guidance from RPP-18486 Appendix C.6.b2 and Koerner, 1998 taking into account that the vertical loading on the drainage layer of the tanks is significantly lower as compared to the cells.

CDN Transimissivity reduction factors per RPP-18486 Appendix C.6.b2, page 631:

$RF_{in} := 1.4$	reduction of transmissivity due to intrusion of adjacent layers into CDN. Due to relatively low loading, value was chosen as mid-range for surface water drains for landfill covers.
$RF_{cr} := 1.25$	reduction of transmissivity due to creep deformation of the CDN. Due to relatively low loading, value was chosen as mid-range for surface water drains for landfill covers.
$RF_{cc} := 1.75$	reduction of transmissivity due to chemical clogging of the CDN. Value chosen as mid-range for primary leachate collection.
$RF_{bc} := 1.75$	reduction of transmissivity due to biological clogging of the CDN. Value chosen as mid-range for primary leachate collection.

$RF_{total} := RF_{in} \cdot RF_{cr} \cdot RF_{cc} \cdot RF_{bc} = 5.36$ total reduction factor.

$\psi_{RF} := \dfrac{\psi}{RF_{total}} = \left(4.198 \cdot 10^{-5}\right) \dfrac{m^2}{s}$ transmissivity, with applied reduction factors.

$Q_{SF2} := \dfrac{\psi_{RF} \cdot (2 \cdot h - D)}{1\ acre} = 578.8\ \dfrac{gal}{acre \cdot day}$ assuming one defect per acre.

As seen above, applying reduction factors to the transmissivity of the drainage layer provides a more conservative ALR than applying a safety factor per guidance from EPA, 1992b. Therefore:

$Q := Q_{SF2} = 578.8\ \dfrac{gal}{acre \cdot day}$ leak rate, with applied factor of safety and assuming one defect per acre in the primary liner.

8.0 Conclusion:

Using Eq (2) with the stated input parameters and a consevative factor of safety, the ALR for each IDF Leachate Storage Tank is approximately 579 gal/(acre*day), assuming one defect in the primary liner per acre.

This value for the ALR is much lower than the capacity of the sump pump that removes liquid from the Combined Sump.

9.0 References:

1. EPA, 1992a, "Liners and Leak Detection Systems for Hazardous Waste Land Disposal Units", published in the Federal Register, Vol. 57, No. 19, Jan 29.
2. EPA, 1992b, "Action Leakage Rates for Leak Detection Systems", EPA 530-R-92-004, Office of Solids Waste Management, Washington, D.C., January.
3. RPP-18486, Rev 1, Integrated Disposal Facility (IDF), Phase I Critical Sysytems Design Report, CHPRC, Richland, WA, 2006.
4. 50423-SUPPL7, IDF Project Installation/Leachate Storage Tanks, CHPRC, Richland, WA, 2006.
5. WAC-173-303-650, Washington Administrative Code - Department of Ecology - Dangerous Waste Regulations-Surface Imponundments
6. Koerner, R., Designing with Geosynthetics, 4th Ed, Prentice Hall, 1998

Appendix A: Datasheet for Leachate Tank Drainage Layer from 50423-SUPPL7, pg. 74

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SKAPS TRANSNET™ (TN)
HDPE GEOCOMPOSITE 220

SKAPS TRANSNET™ geocomposite consists of SKAPS GeoNet made from HDPE resin with non-woven polypropylene geotextile fabric heat bonded on both sides of the the geonet.

Property	Test Method	Unit	Required Value			Qualifier
			With 6 Oz.	With 8 oz.	With 10 Oz.	
Geonet						
Mass per Unit Area	ASTM D 5261	lb/ft^2	0.17	0.17	0.17	Minimum
Thickness	ASTM D 5199	mil.	220±20	220±20	220±20	Range
Carbon Black	ASTM D 4218	%	2 to 3	2 to 3	2 to 3	Range
Tensile Strength	ASTM D 5035	lb/in	45	45	45	Minimum
Melt Flow	ASTM D 1238[3]	g/10 min.	1	1	1	Maximum
Density	ASTM D 1505	g/cm^3	0.94	0.94	0.94	Minimum
Transmissivity[1]	ASTM D 4716	m^2/sec.	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	MARV[2]
Composite						
Ply Adhesion (Minimum)	GRI GC7	lb/in	0.5	0.5	0.5	MARV
Ply Adhesion (Average)	GRI GC7	lb/in	1	1	1	MARV
Transmissivity[1a]	ASTM D 4716	m^2/sec	$2.75x10^{-4}$	$2.25x10^{-4}$	$2.0x10^{-4}$	MARV
Geotextile						
Fabric Weight	ASTM D 5261	oz/yd^2	6	8	10	MARV
Grab Strength	ASTM D 4632	lb	150	225	270	MARV
Grab Elongation	ASTM D 4632	%	50	50	50	MARV
Tear Strength	ASTM D 3786[4]	lb	60	90	100	MARV
Puncture Resistance	ASTM D 4833	lbs.	95	130	165	MARV
Mullen Burst	ASTM D 3786[4]	psi	325	450	550	MARV
Water Flow Rate	ASTM D 4491	gpm/ft^2	125	100	75	MARV
Permittivity	ASTM D 4491	sec^{-1}	1.63	1.26	0.94	MARV
Permeability	ASTM D 4491	cm/sec	0.48	0.3	0.30	MARV
AOS	ASTM D 4751	US Sieve	70	80	100	MARV

IDF Project

Notes:

1. Transmissivity measured using water at 21 ± 2°C (70 ± 4°F) with a gradient of 1.0 and a confining pressure of 15000 psf between stainless steel plates after 15 minutes. Values may vary between individual labs.
   1a. Transmissivity measured using water at 21 ± 2°C (70 ± 4°F) with a gradient of 0.1 and a confining pressure of 10000 psf between stainless steel plates after 15 minutes. Values may vary between individual labs.
2. MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.
3. Condition 190/2.16
4. Modified

Appendix B: H-2-830869-001, IDF Leachate Tank Foundation Plan, Section and Details